# MR. GILBERT'S REPLY

TO

# MR. ALLEN'S NEW DOCTRINE

ON

THE PRINCIPLE OF STABILITY

IN

# FLOATING STRUCTURES.

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# REPLY, &c.

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*Propriety of this reply.*

It was supposed that the relative merits of the balance and sectional docks had been fully discussed. But Mr. Horatio Allen, under the title of a "civil engineer," has recently advanced a new doctrine on the principle of STABILITY in floating structures, which is averred to be very important, involving a vital principle—a principle on which, avowedly and confessedly, depend the superior claims of the sectional over the balance plan. It is singular that this principle, on which all now is apparently made to depend, should have remained undisclosed so long.

*Mr. Allen's position.*

He is presented, in a preface to his statement, published and circulated among members of Congress, as "a civil engineer of great eminence," as if he had no interest in the sectional dock. He says, in his note to S. D. Dakin and others, dated March 25, 1846, "As it [my statement] is connected with a very important *public* object, I have no hesitation in *permitting* any use to be made of my remarks which, in your judgment, may be found advisable." This *consent* is given under an apparent sense of *public duty*. It is proper it should be understood that Mr. Allen occupies the position of *contractor* with the Sectional Dock Company for the building of their dock, if it should be ordered by the Government. He says, therefore, in one part of his statement, "as my opinion was formed some years before I had any idea of being in any way *connected* with the question, I do not withhold that opinion." In House Doc. No. 163, 2d sess. 28th Congress, page 35, will be found documentary evidence of this position of Mr. Allen, in a responsibility tendered as *contractors* for the building of this dock, by the firm of *Stillman, Allen, & Co.*

*Mr. Allen's new doctrine.*

It hardly need be said that a diploma is not a certain test of scholarship; or that a profession of science is not sure evidence of proficiency in it; or that engineering is a scientific profession; or that a mistake in the practical part of this profession may be fatal. The announcement of a new principle in science is a high pretension, and ought to be well considered before it is adopted—more especially if any thing important is depending. Mr. Allen has evidently risked this pretension, and staked all upon it. His new principle professes to determine what makes *stability* in a floating structure. He says, "I have committed to paper these views as to the *relative stability* of the sectional and balance docks submitted by me to the Naval Committee of the House." Also, "I have taken care to *confine* myself strictly to that question." He did not, however, so confine himself, but went over the entire ground of debate between the two docks, as the statement will show. His propositions in support of his new principle are as follows:

"The stability of the two plans of docks depends, like that of all floating structures, on the presence and operation of adequate cause to restore the docks to an upright position, as soon as the force which has made it careen ceases to act; and this cause is found in the change of the form of the section of displacement which attends the act of careening. This change is not affected in any important degree, *in the cases in question*, by the position of the centre of gravity in reference to the water line; and as it appears that some misapprehension prevails on this point, I will briefly state what are the *well-established principles* in reference to it.

"The first position is, that when a body floats at liberty in water, and a force be applied to turn it partly over, like that of wind on the sails and spars of a ship, the centre around which *it will turn* will be the centre of gravity of the body, and this will be the case whether the centre of gravity be above or below the water line."

Mr. Allen has, in the first of the above sentences, given a partial glimpse of the truth, but has omitted a most important particular, viz: the height of the centre of gravity above that of the displaced mass of water.

He proceeds in an attempt to illustrate and establish these propositions to the eye by diagrams, setting up the pretension of a *demonstration.*

Let us see what they prove. Cylinder A, on figure 1, only demonstrates that a cylinder of iron, of equal thickness in all its parts, may be made so heavy as to be of no practical use as a floating structure. By placing a weight on the top of cylinder B, it will then exemplify the principle of top-heaviness in the sectional dock by turning over and coming to a state of rest with the weight at the bottom. The same weight placed in the bottom of cylinder C would cause it to remain at rest, without turning over, which exemplifies the principle of the balance dock.

But, if the opposite principle can be established, that of Mr. Allen manifestly falls to the ground—is nothing; and that, perhaps, will be the shortest way to determine this question.

### *Test of Mr. Allen's new principle.*

The opposite principle is, that a floating structure *ballasted* is more stable than the same structure with the same burden on a deck. This is precisely the question raised by Mr. Allen. This simple statement ought to be enough, as it is supported by all experience. The Indian takes care to put his family, and whatever burden he has to carry, in the bottom of his canoe. But, according to Mr. Allen, it would be equally safe to put them on the top, because "the change in the form of the section of displacement attending the act of careening" will be the same, whether the load be placed in the bottom of the canoe or on the top. According to Mr. Allen, the Royal George, of the British navy, lying at anchor in a quiet roadstead, with her ballast taken out, and her armament on deck, ought not to have upset, and gone to the bottom, as she did. According to Mr. Allen, it is equally safe to load a vessel on deck as in the hold. According to Mr. Allen, the first sectional dock built in New York ought not to have upset with its burden on, as in several cases it did. According to Mr. Allen, it was altogether unnecessary to add the end floats to the sectional dock, and to lash the entire structure, thus extended, to upright posts, to prevent such disasters. For Mr. Allen's principle is, that the stability of a floating structure is not augmented by having its centre of gravity below the water level—such for example, as would be the case with the balance dock, having in her the ship of the line Pennsylvania, with all her armament and stores, weighing 5,200 tons; and that the stability of the sectional dock would not be diminished, when its centre of gravity, under the same burden, *if it could bear it*, would be nineteen

feet *above* the water level! Mr. Allen admits that the balance dock, with a ship in it, is more stable than the ship itself afloat in the water; but he admits this after having *assumed*, without proof, that the sectional dock, by the principle of its structure, is fifty per cent. more stable than the balance dock, for the sake of showing the *wondrous* stability of the sectional dock!! This admission, certainly, is quite sufficient for all practical uses of the balance dock.

This whole question is involved in and decided by two words, with practical men—*top-heaviness and ballast*—or, to use a more homely phrase, *top-heaviness and bottom-heaviness.* Every practical waterman understands this, and surely "an engineer of great eminence" ought to understand it. A man that presumes to take his station, astride, on the two upper edges of an Indian canoe, that is afloat, will chance to have a pretty quick demonstration of the validity of Mr. Allen's new principle. An Indian would laugh right heartily to witness the scene, and tell the presumer to get in the bottom next time. The secret of this operation, demonstrating stability or instability, lies in the position of the centre of gravity of the canoe and its burden, in relation to the water level. But, according to Mr. Allen, stability is not affected by the position of the centre of gravity in such relation. An expert circus rider can possibly ride erect, even on two horses; but most gentlemen prefer sitting low in the saddle, on one substantial support.

The balance dock is one rectangular vessel; receives the ship between its sides, and bears her weight upon its bottom and sides; the weight of the ship being in part transmitted to the side walls by the shores and props. The weight of the ship, thus added to the dock, carries the common centre of gravity of the mass to a line below the water level. This is stability, as opposed to top-heaviness. The ample buoyant power of the balance dock admits of ballast of iron ore (which is used, and not water, as Mr. Allen represents) of any desired amount, deposited in the side chambers.

The sectional dock is a number of like rectangular vessels with decks. These vessels are sunk down, and the ship raised upon them, the weight of the ship bearing upon the top of the decks. The effect of the ship's weight on the sectional dock is the same as placing the cargo of a ship on her deck, and leaving the hold empty. It lifts the centre of gravity up to the highest possible point, and produces top-heaviness, the opposite of stability.

In a balance dock, the keel of a ship of the line, weighing 5,000 tons gross weight, will be ten feet below the water level, and the centre of gravity of the dock and ship together will also be below the water level. On the sectional dock, the keel of the same ship will be three feet *above* the water level, the ship being poised in the air, and the centre of gravity of ship and dock together *nineteen* feet above the water level. The balance dock has the ship *in* it, like a cargo in the hold; the sectional has the ship *on* it, like a cargo on deck, and no ballast. Which, then, is the most stable? Mr. Allen says the latter is! and he is "an engineer of great eminence!"

The reason why a ship that has careened by the action of the wind on its sails rights itself in a calm, is, because of the low point of its centre of gravity in relation to its basis; and the reason why a ship that has careened on the sectional dock will not right itself without *special* effort, is, because of the elevated point of the centre of gravity of the ship and dock united, also in relation to its basis. The effect of placing a load on the top of a balloon would be an illustration of the balancing power of the sectional dock. If a man should be exactly balanced on a small tank, with end floats in the water, on the principle of the sectional dock—the tank and

floats being of such dimensions as to submerge the tank as a ship does on the sectional dock tanks—he would find it difficult enough to maintain his balance, even with the aid of a stick in each hand resting on the end floats. The tank helps him not at all, as its upper surface is supposed to be on a level with the water. This, as will be seen, is the dock itself.

### *Examination of Mr. Allen's propositions.*

Having established the opposite of Mr. Allen's principle, the question is concluded. Nevertheless, it may cast some further light on the subject to examine his propositions, stated under a foregoing head. In the first place, no dock fit for such an important use ought, by any possible cause, to be liable to *careen permanently* under its burden. But as the sectional dock *is* liable to such an accident, and has upset a number of times, it was necessary to provide a theory that might *seem* to obviate the difficulty.

The true questions at issue between the two docks are these: Which of them has a stability of itself, derived from its construction, and independent of constant extraneous mechanical effort to maintain it? and which of them has, while maintained, the greatest *amount* of stability while the vessel is in a situation to undergo repairs? It cannot be doubted that, in respect to the first point, the advantage is entirely with the balance dock. The sectional dock relies wholly on the end floats for its stability, and the floats depend on trains of shafting, tooth-couplings, wheels, racks and pinions, tangent screws, and other mechanical contrivances, for raising and lowering the floats. These, in combination with the steam engine and appendages, form a complex system of works, the derangement of a single piece of which would interfere with the power of producing or sustaining the *forced* equilibrium, under which the dock is always compelled to act, when its tanks have exhausted their lifting power, and remain with their upper surfaces at or below the water level. The tanks, thus submerged, have, by themselves, no determinate position, but tend to escape from their constrained situation whenever the centre of gravity of themselves and their load ceases to be vertically above the centre of gravity of the mass of water displaced by them. In proportion to the available displacement of the end floats, and to their distance from the central line of the dock, will be their power to restore the erect position after any disturbance, provided the disturbance has not been accompanied by any derangement of the props and supports, or any irregularity in the position of the sections. But such derangement and irregularity, in so complicated a structure, with its complex machinery, are not unlikely to follow a disturbance.

Though, in revolving about its centre of gravity, "the change of form in the section of displacement" is not materially dependent on the height of the centre of gravity of the dock and ship above the centre of gravity of the water displaced; yet that which Mr. Allen either forgot, or intentionally omitted to state, is nevertheless true, viz: that the *stability* of the floating body is affected by every elevation of the centre of gravity, whether the body be one solid piece, or made up of several loosely connected parts—whether it be a balance or a sectional dock. Every such elevation, when the dock careens, shortens the "*equilibrating lever*," or, which is the same thing, shortens the horizontal distance between the vertical line passing through the centre of gravity of the floating body and that passing through the centre of support—that is, the centre of gravity of the displaced mass of water.

Mr. Allen says: "The position of the centre of gravity with regard to the *water line* enters the question *only* in determining the position of the vertical line passing through the centre of gravity;" but he carefully evades or slurs over, with his italicised "*only*," the essential fact that the position of this vertical line is one of the most important elements of every computation in regard to *stability*. The higher the centre of gravity is on the vertical which passes through it in the undisturbed position, the nearer will the vertical through the same centre, in the inclined or careening position, be to that which passes through the centre of gravity of the displaced mass, until the position becomes *absolutely* unstable.

Mr. Allen must have counted largely on the ignorance and credulity of those for whose eye his statement was intended, if he supposed they could be led into the belief that a given floating body, with its centre of gravity 19 or 20 feet above the water line, is just as stable as the same body would be with its centre of gravity on a level with that line. No importance can be attached to "the water line," except as indicating *proximity* to the centre of gravity of the displaced mass, in which sense it is material.

Mr. Allen ought to have known, before advancing so palpable an absurdity as he has done, that, for every floating body capable of assuming a determinate position, there is a certain *point* in a vertical line drawn *upward* from the centre of gravity of the mass of liquid which it displaces, *above which* (point) the centre of gravity of the body itself can *never* be carried, without destroying all stability, and causing the body to upset. That point, to all who understand the subject of *flotation*, is known under the name of "the METACENTRE." He ought also to have known, that, in exact proportion as we elevate the centre of gravity of the floating body, above that of the displaced mass, all other things being equal, in the same proportion do we diminish the stability of the floating body or system.

If the two docks be supposed to have their centres of gravity of dock and load at an equal elevation from the centre of gravity of the displaced mass of water, a comparison may be made by considering the surface covered by the effective portion of each dock. The effective portion of the balance dock, for a ship of the line, is its whole horizontal area—equal to 21,600 square feet—and that of the sectional dock, for the same ship, is the area of its 12 end floats, (its tanks being submerged,) equal to 6,480 square feet. The mean distance of the effective area of the balance dock from its central line is $22\frac{1}{2}$ feet; that of the sectional dock is $57\frac{1}{2}$ feet. Now, $21{,}600 \times 22\frac{1}{2} = 486{,}000$ for the balance dock, and $6{,}480 \times 57\frac{1}{2} = 372{,}600$ for the sectional dock. This supposes the weights resting on the water the same in both cases. But the principle of construction of the sectional dock requires that as little weight of materials as possible should be employed in building it. It must be light, to avoid increasing its draught of water. It cannot afford to receive any ballast to keep low its centre of gravity; whereas the balance dock can be built of iron of any desirable thickness, and, should its own weight be 3,000 tons, it can, without impairing any of its important properties, receive 3,000 or 4,000 tons of solid ballast on the bottom of its side chambers—an arrangement by which its centre of gravity, without the ship, would be *below* the centre of gravity of the displaced mass of water, and, consequently, its separate stability would be *absolute;* so that, if put into the water on edge, it could not fail to come right side up, and to remain afloat.

All these facts, which have a direct bearing on the stability of the balance dock, and which prove the lightness and comparative frailness of the sectional dock, it did not suit Mr. Allen's purposes, as a *contractor*, to enlarge upon.

The demonstration above shows that the "equilibrating" power of the two docks, is as 4,860 for the balance, and 3,726 for the sectional dock, when their centres of gravity are equally elevated, which, in fact, is never the case. Inasmuch, therefore, as the sectional dock must always carry the centre of gravity of itself and load *much higher* than it is necessary for the balance dock to do, the disadvantage against it, as to stability, will be materially increased by this cause, as already indicated. Besides, some water will always remain in the bottom of the tanks; and if the tanks be without partition, it will flow towards the depressed end, and increase its tendency to descend still lower. If the tanks be divided, the same effect will take place, though to a less extent.

In order to get buoyancy and stability, the sectional dock resorts to an increase of breadth greatly beyond the requirement of the largest ships. Its area ($192 \times 135$) will be 25,920 square feet, or three-fifths of an acre. It is a singular fact, that with all these pretensions of *stability* in the sectional dock, they should not dare to trust it afloat with its load on, but take care to bind it to elevated posts or masts alongside of the wharf, connecting it with *terra firma*, as any one may see who visits the dock in New York.

## *Value of certificates.*

Mr. Allen says: "I have taken care to *confine* myself *strictly* to the question of *relative stability*." He did not, however, but went over the whole ground of debate between the two docks, and added what professes to be a certificate of "*all* the ship builders in New York." As some weight seems to have been attached to the certificates in favor of the sectional dock, it may be proper to say, that certificates of and from *all* the same classes of persons have been presented in favor of the balance dock, as the files of the Navy Department and of committees of Congress from year to year will show, though not perhaps so numerous and full. Knowing how such certificates are generally given, as a *favor solicited*, when the persons who sign them do not usually know what they sign, the proprietors of the balance dock, who could have loaded the tables of Congress with such papers, and of equal if not of greater value, have chosen to rely on the palpable merits of their dock, and on the intelligence of members of Congress. Of what value, for example, is the latest certificate presented by Mr. Allen, from seven merchants of New York? They are no doubt good *merchants;* but would a wise legislator rely on their scientific knowledge of the matters to which they certify? They simply certify to Mr. Allen's *views*—that they are of the same *opinion*. The value of that opinion is shown in the foregoing pages. As to "*all* the ship builders in New York" being on the certificate of this class, as stated by Mr. Allen, it is incorrect; those who took time to consider what they were asked to do, refused to do it. The certificates may perhaps be considered as good for one side as for the other—worthy, doubtless, of some respect, but not entitled to the claim of carrying with them an intelligent and scientific knowledge of the subject.

The balance dock has higher authority than this to cite: first, a decision in its favor of nearly, if not quite, all the scientific commissions, domestic

and foreign, that have sat on the comparative merits of the two docks; and next, the fact that the balance dock has been *preferred* to the sectional in various foreign countries, and in several parts of our own, while not a single sectional dock has been built, except at the city of New York and at Black Rock—the latter being defunct long since, and the former being usable only by being tied to posts on shore, to keep it steady! Two balance docks have been built and long in use at Amsterdam, frigate size; and another has been ordered by the Dutch Government for Batavia, for naval and commercial purposes; one is built and in use at Havre, ship-of-the-line size; one at Marseilles, for steam ships; a commission of the French Government has reported in favor of one at Toulon, where there are three stone docks; one, frigate size, is under contract for Rio Janeiro; the Sardinian Government has sent to New York for a building model; one, sloop-of-war size, is built and in use at Charleston, South Carolina; one, ship-of-the-line size, is launched at New Orleans; and one is now in progress of negotiation for Mobile, for the largest commercial craft, to be used as a camel as well as for repairs. Is all this testimony nothing? Is it not more valid than certificates from those who are *solicited* to give an *opinion* on a subject which they know little or nothing about?

*Dry Dock at Pensacola.*

The importance of a dock at Pensacola, in the present state of the country, must be felt by all, and it is admitted that the necessities of the Government cannot afford a disappointment by failure or delay. It is doubtless indispensable that a dock at Pensacola, or a dock any where else, should be able to take up a ship of any class that can enter the port, with all her armament and stores on board. Without such capacity, it will not answer all demands. Let full and satisfactory bonds for the fulfilment of this and other objects be required, and the undersigned will cheerfully acquiesce in any decision of the Government, whether it be to order his plan or that of his opponents.

The general merits and claims of these two kinds of docks having been fully discussed before, the undersigned has thought proper to confine himself chiefly to a consideration of the new doctrine advanced by Mr. Allen with such high and confident pretensions. The unsoundness of that doctrine, it is hoped, has been fully and satisfactorily exposed.

JOHN S. GILBERT.

New York, *May* 20, 1846.

P. S. Since writing the above, another pamphlet from "Horatio Allen, Civil Engineer" (!!), has appeared, setting forth the superior claims of the sectional over a stone dock, after having demolished the pretensions of the balance dock in the *manner* already noticed. One remark alone is sufficient to answer the whole: Mr. Allen's averments to the contrary notwithstanding, of the fitness and capabilities of the sectional dock, in connexion with a stone basin and railways, to land ships high and dry, *it is yet a problem to be solved by experiment.* In a joint report made to the Secretary of the Navy, February 4, 1846, by Com. M. C. Perry and Naval Constructor S. Hartt, they say "that a vessel may be hauled upon land as conveniently from the balance as from the sectional dock, by the hydraulic cylinder;" while the *exclusive* capabilities of the balance dock to be used as a *camel*,

are acknowledged to be of the highest importance. In the report of the commission composed of Captains Kearney and Wyman, and Engineers Talcott and Sanger, (House Doc. No. 163, 2d sess. 28th Congress,) they speak of "the difficulties and dangers attending" the project of basin and railways in connexion with the sectional dock—of course as an *unsolved* problem—and they say "it will be far more expensive for repairs than the mode now practised."

J. S. G.

*Copy of a letter from Commodore Stewart.*

PHILADELPHIA, *May* 28, 1846.

DEAR SIR: I have received your letter of the 23d instant, with the enclosed bill, now before the House of Representatives, for the construction of a floating balance dock at Philadelphia, and a floating sectional dock at Pensacola; to all of which I have given my most deliberate consideration.

There is no position at the Philadelphia naval station where a sufficient depth of water can be retained at all times and in all tides for the docking of a ship of the line, even *without* her armament, in a sectional dock, in consequence of the greater draught of water required by that kind of dock, for the lifting or submerged tanks under it. As the bill provides very properly for the construction of a "balance dock" at this station, none of these disadvantages will accrue in consequence; and as the balance dock will not require a permanent insular wet dock for its retention, it can be at all times moved to any point or place most convenient for its purposes, and will also possess the *camel* properties of lifting and bringing to any place in the river a vessel drawing more water than the river admits of. This is a highly important consideration, and a decided advantage which the balance dock possesses over the sectional one. It is on this account that I regret the balance dock was not also contemplated for Pensacola; and I apprehend it will be found in practice at that place, that the sectional dock will soon be rendered useless by the filling up of the permanent wet dock in which it is retained, as the downward currents are constantly carrying moving sands and filling up all recess places open to those waters. This could not occur with the balance dock—which is always capable of being removed from any place which may, from any cause, become unsafe, to one more secure. Now, I deem this fact an important consideration for the navy yard at Pensacola, because, as that place may be bombarded from the sea in its rear, a floating dock of the sectional kind, with a ship in it, would be liable to be set on fire, under such circumstances, because it could not be removed, while the balance dock could be taken out of the way, up the Escambia river, if necessary. Further: without the *camel* properties of the dock at Pensacola, *to lift ships of the line over the bar*, there could be no ships of the line to dock at that place.

I hope the committee or House will amend the bill so that a balance dock may be constructed at both places.

Very truly your friend and obedient servant,

CHS. STEWART.

WOODBURNE POTTER, Esq., *Washington, D. C.*